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# Nanoscale investigation of domain evolution behavior in rhombohedral $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ relaxor ferroelectric single crystal

Q. Hu[1], D.O. Alikin[2], P.S. Zelenovskiy[2], D.S. Chezganov[2], Y. Zhao[1], X. Liu[1], P. Luan[1], W. Zhao[1], Y. Zhuang[1], X. Fu[1], Zh. Li[1], F. Li[1], Y. Tian[1], L. Jin[1], Zh. Xu[1], V.Ya. Shur[2], X. Wei[1]

[1]*Electronic Materials Research Laboratory, Key Laboratory of the Ministry of Education & International Center for Dielectric Research, School of Electronic Information, Xi'an Jiaotong University, Xi'an 710049, China*
*wdy@mail.xjtu.edu.cn; xuzhuo@mail.xjtu.edu.cn*

[2]*School of Natural Sciences and Mathematics, Ural Federal University, Ekaterinburg 620000, Russia*
*vladimir.shur@urfu.ru*

Domains and domain walls play key roles in determining the properties of ferroelectric materials. Investigations on domain evolution behaviors with external temperatures and electric fields are of significant scientific value and meaningful for practical applications. Scanning probe measurements are performed in this paper to study the domain evolutions under external temperatures and local electric fields at nanoscale. Results by the piezoresponse force microscopy (PFM) demonstrate that the domain structure clearly changes during phase transitions, which is also in accordance to the macroscopic dielectric behavior. Kelvin probe microscopy is introduced to study dynamics of artificially created domains. Experimental results show that the artificially created domains are stable during the testing time range. Moreover, the time-dependent surface potential decay of artificially created domains can be classified into three groups by the temperature range upon heating, which is also correlated to the phase structure of the crystal at each temperature region. We believe that our work can deepen the understanding on domain kinetics of the PMN-PT single crystals and also provide instruction on the application of such relaxor ferroelectric single crystals on digital memory devices.